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VISUAL, CUTANEOUS, AND KINAESTHETIC GHOSTS

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	PAGE
A. Introduction.....	349
B. Visual Ghosts.....	350
I. The Nocturnal Visual Ghost.....	350
II. The Diurnal Visual Ghost.....	357
C. Cutaneous Ghosts.....	364
D. Kinaesthetic Ghosts.....	369

A. INTRODUCTION

The questionnaire method, which has been so often employed in this occult field of psychology, has failed to yield sufficiently consistent results to enable one to formulate a satisfactory theory of visual ghosts. Unfortunately, ghost stories, like fish stories, are too often either pure creations or gross misrepresentations. People can always be found who deliberately distort facts as long as they realize that no one is qualified to contradict their statements. False ghost stories are often motivated by beliefs in the supernatural, or by the mere desire to interest or scare others. A ghost story of one who has been trained from his cradle days to be an aggressive spiritualist, is generally of a more exciting nature than one told by an anti-spiritualist. Ghosts and rumors of ghosts have ruled societies throughout the ages of human history; and the reign of the rumors has perhaps caused the greater terror. Those investigators, who have made use of the questionnaire method, failed utterly to distinguish between ghost and mere rumor. We shall censor these stories and shall limit ourselves to only those ghosts such as have been produced and reproduced under controlled conditions.

It is a duty of the psychologist to attempt to account for the fact that a *limited number* of people, apparently of all races, have observed certain appearances which they have been willing to call ghosts or spirits. The visual ghosts will be of primary interest to us; but, in order to make our theory more comprehensible, we shall discuss also a number of other phenomena which are fundamentally the same as the visual ghosts, and which are fortunately not shrouded in super-

stition. The latter phenomena we may profitably call cutaneous and kinaesthetic ghosts.

B. VISUAL GHOSTS

1. *The Nocturnal Visual Ghost*

Experimental results indicate that this traditional ghost is only a *positive after-image of long duration*¹ which becomes revived by a stimulus of such extreme insignificance that the *immediate* visual effect produced by it may find no place in the ghost story. If we choose to speak in Pawlow's terminology, we may call this ghost a *conditioned* visual response to a previously perceived more or less complex pattern of visual stimuli.

In a previous article² I related one of my experiences with the positive after-image which I suggested might be of interest to spiritualistically inclined persons. This was an account of my illuminating my retinas through my closed eyelids and thereby reviving a positive after-image which I had experienced about fifty minutes before. Recently I have succeeded in reviving remarkably distinct positive after-images from six to eight hours after the original ones were experienced. I waited in the darkness from five to ten minutes, and then fixated and illuminated my hand or a particular white surface steadily for about one second. I observed a continuous positive after-image which often lasted as long as a minute and a half. Then, after sleeping six or eight hours in a very dark room, and before opening the eyes, I illuminated the retinas with a flashlight, but so very slightly that I did not become aware of the red of my closed eyelids. Not every morning, but sometimes, the after-image was revived. It occasionally appeared in almost its original distinctness, and once or twice it endured about as long as originally. The ghost frequently appeared the first time the retinas were slightly illuminated, but sometimes it did not. When the first trial proved unsuccessful, I illuminated the retinas again and again until it did appear, or, until I gave up in despair. I have succeeded in reviving a single positive after-image a number of times, but not in immediate suc-

¹ A positive after-image of long duration and the essential conditions for obtaining it are described by Helmholtz in his *Physiologische Optik* p. 504. On p. 506 he states that the positive after-image of bright clouds viewed thru a window for about $\frac{1}{3}$ second, disappears after about 12 seconds.

² Positive After-Images of Long Duration, this JOURNAL, XXVII, p. 334.

cession. I made each time a pause of just about as many seconds as the ghost had remained with me, and then I slightly illuminated the retinas. When this rule was strictly obeyed, I found it possible to revive the after-image five or six times in this slow tempo. It seems that, in order to revive an after-image after such a long lapse of time, the retinas must be illuminated just as the otherwise unnoticeable positive after-effect is on the verge of reappearing. That a positive after-effect does reappear a number of times without the retinas becoming reilluminated, is a matter of frequent observation. It is observed to grow fainter and fainter until it can be no longer detected; and we shall assume that at least some of the visual structures involved, continue thus periodically to refunction for an indefinite time. This, we shall suppose, is especially the case when the individual is inclosed in darkness, under which condition the retinas are not being strongly stimulated.

If my retinas should have become similarly illuminated in the morning by something which was not under my control, as was the flashlight, I should very likely have seen a ghost when I was not looking for it. This would more likely occur if I should turn out the light, and, after remaining in the darkness for a few minutes, turn on the light for a short interval, perhaps to see if a certain article is in its proper place. If my retinas should happen to become properly illuminated a few hours later, I should very likely see a ghost of the last observed object. If such should appear during my sleep, I should be inclined to call it an unusually vivid dream, the nucleus of which is this object; I might just as well consider it a revived positive after-image or a ghost.

Let us now imagine the following possible conditions. Two persons, A and B, are in a room and are ready to go out. A turns out the light, and they depart in the darkness together. After a few minutes, B discovers that he has forgotten his watch, and they both return. A turns on the light long enough for B to get his watch and looks at him during the short interval. They then go away for good, separate, and A's path leads him through a dark forest. While in the forest, he chances to pass through a small glade and thereby slightly illuminate the retinas just as the ordinarily unnoticeable positive after-effect of B is on the verge of reappearing. In the darkness beyond the glade, A will then see a ghost of B, but will he recognize it as B's image? These ghosts are not always so distinct and clearly defined that one can say with certainty that it is the image of this and not

of that person. If A should be spiritualistically inclined, we might expect him to say, "Oh, that's the spirit of my dead friend." He may, in telling his ghost story, relate how the spirit or ghost of his dead friend approached him one night in a dark forest; how it floated about him for a time; and how it then either gradually or suddenly vanished; and not even think of mentioning the fact that he had just walked through a glade.

There are many other conditions under which the ghost might appear. On a dark cloudy night, A might be walking in the open when the moon chances to shine through a small break in the clouds just at the right moment to revive the after-image. A might also glance at a distant light, or even at a near-by bright surface which stands out in the darkness, such as a white tomb-stone he sees while passing a graveyard. Or, if he should be brave enough to approach a deserted house or castle, where, as he has been told, horrible crimes have been committed, he might be expected to glance rather carefully at all the bright objects near him; and furthermore, what is equally important, he might be expected to walk rather timidly and occasionally stand perfectly still. This latter condition is important, because a positive after-image of long duration does not appear, or, if it has already appeared, it either grows weaker or vanishes completely when one makes a pronounced sudden movement. Experimental results indicate that A might easily keep the ghost away by whistling. He might also put the muscles of his body under tension, perhaps slap his hands together, or shake his fists in the air, and make the further consistent response of saying, "I am not afraid," and thus reach the house or castle without being intercepted by a ghost.

The two following ghost stories are typical of a large number of the many hundreds which have been related to me since I first began serious investigations in this field. A certain French duke, while sleeping in his château, was awakened by a peculiar knocking at his door. Almost immediately, a human figure with two heads entered through the closed door, floated about in the room for a short time, and then gradually disappeared through a wall. This gentleman related his experience to an elderly lady who was at the same château. In an excited way, but with an honest look, she said, "Just about two months later, I had *exactly* the same experience. I was awakened by *exactly* the same knocking at the door, and, thinking it was a maid, I said, 'Come in,' but no one responded, and I thought immediately of the two-

headed person. Well, as you may imagine, my heart almost stopped. I was absolutely *powerless*, and I did not dare look around, because I knew that two-headed person was there behind me." When I asked her if she saw anything, she replied, "No, but everything told me it was there *just* behind me." If this lady had been untruthful enough to emphasize her ghost story by asserting that she really saw the ghost, I should have considered this a typical case of contagious ghost seeing. Or, if she had glanced at a bright object before she became 'powerless,' as the duke perhaps did when he heard the noise, she might have thereby really caused a positive after-image of some previously perceived visual pattern to be revived. This would have been a case of real ghost contagion, due to the fact, however, that the duke's story caused her to behave in an ideal way to cause an after-image to be revived. The duke's story caused her to become, as she expressed it, 'powerless'; and we might here remark that a fixating person is a 'powerless' one. It might also be mentioned in this particular connection, that a fatigued person is likewise, often at least, a fixating person. Observations seem to indicate that the well known hypnagogic phenomena, which appearances are fundamentally the same as our ghosts, generally arise under conditions of unusual muscular fatigue. That the duke's ghost possessed two heads, is nothing unusual in a positive after-image. One can easily obtain a similar effect by fixating two persons, one of which is somewhat behind the other, by turning the head to the right or to the left while fixating a single person, or by holding the head and the eyes still while the fixated person moves only the head.

There is really no apparent reason why many of the traditional ghosts should not be the revived positive after-images of deceased persons. In this connection it is interesting, that while observing corpses, people are not ordinarily engaged in making such pronounced movements as are involved in the activities of dancing, laughing, whistling, or perhaps singing such popular songs as are accompanied with pronounced bodily movements. On the contrary, even those who do not actually weep often stand before the corpse and fixate it carefully, sometimes so very carefully that many of the objects in the field of vision subjectively disappear. Others, in weeping, shut out for a long time the light rays from the eyes, take another glance at the corpse, and then weep again in the same way. The weeping is often, at least after several hours of frequent weeping, of a rather silent nature, in the

sense that no very pronounced movements are involved in it. These are ideal conditions for preparing one to see ghosts. It is by no means necessary that the mourner should at the time see what we call a positive after-image of the corpse; for a large part of the percept is, after the first few moments of exposure, no longer dependent upon the objective stimulus for its continued existence, and is therefore fundamentally the same as the positive after-image which, under the condition of darkness, exists independently of the objective visual pattern. The positive after-image is evidently in progress while the surface is being observed. It is only the positive after-image, and not the entire percept, which can be revived by an insignificant visual stimulus; the entire composite visual experience can be revived only when the original objective pattern is presented under exactly the same conditions as previously.

If the mourner should leave the corpse and pass immediately into the darkness, the likelihood of his later seeing a ghost would be greater than if he should leave and remain for a while in daylight, where the retinas become in the meantime strongly stimulated in a variety of ways. In this connection, I must recall the fact, that after I had spent about forty minutes in a well-lighted room, and then about ten in the darkness, a ghost of a previously fixated person appeared when I illuminated the retinas through the closed eyelids. Whether this was the ghost of the person as I last saw him in the light, or whether it was the revived after-image of him which I had observed about fifty minutes before in the dark-room, I now feel unable to say, for, as I distinctly remember, he stood before me in about the same way in both instances. However, a few persons insist they have seen ghosts of me even many days after I showed them a positive after-image of myself. It seems as if the Chinese see such ghosts more frequently than people of other races. This, I think, should be considered in connection with some of the facts I reported in my article on 'The Biological Significance of Eye Appendages of Organisms'³; a study of this sort might possibly throw considerable light on many of the traditions of the Chinaman.

We have previously assumed (p. 2) that at least some of the structures involved in producing an after-image pattern periodically refunction for an indefinite time; and, that if when these few structures are just on the verge of refunc-

³ This article has been accepted for publication in this journal, but has not yet appeared.

tioning, the retinas chance to be restimulated in somewhat the same way as originally, these, and also many other visual structures which previously functioned simultaneously with these, will refunction and accordingly produce a distinct positive pattern. This postulation was made in order to explain the fact that a positive after-image can be revived only *occasionally* by a given insignificant stimulus. Certain facts seem to support our assumption. It is not a theory, but a matter of observation, that a positive after-image often alternates with a negative after-effect of about the same duration. When the positive effect lasts thirty seconds (this seems to approximate the maximum duration for the normal untrained individual who fixates carefully), the duration of the negative one is also just about thirty seconds. After only two or three alternations, however, the negative effect of the white surface can be, as a rule, no longer noticed, while the positive one may be detected still several times. As I pointed out in the article on positive after-images already referred to, (p. 331 of that article), if the retinas become again illuminated in the same way just as the faint positive after-effect is on the verge of reappearing, the resulting after-image is unusually distinct. If the retinas become reilluminated with the previously used pattern just after the faint positive effect has vanished, a distinct positive after-image generally follows, but observations show that this one is almost invariably less distinct than the one which is caused to occur simultaneously with the faint one. On the other hand, this positive after-image is often of much longer duration than when it is caused to coincide temporarily with the faint one. Apparently, the duration of this effect amounts to the duration of the directly produced effect plus that of at least a part of the ensuing one that now becomes revived to an extraordinary degree of distinctness by the visual responses which are in progress when the otherwise faint after-effect begins to reappear.

Let us call this directly produced after-image A, and the periodically appearing positive after-effect which this time follows A, let us call B. Since both A and B consist of many visual responses, we may speak of the A- and B-responses, or of the A- and B-patterns of simultaneously occurring responses. A occurs, e. g., 15 seconds before B, but A is still in progress when B appears, and consequently, B is revived to unusual distinctness by the responses of the A-pattern. If this occurs frequently, the A- and the B-patterns become associated in the particular order AB, and later, when no positive effects of the objective pattern can be observed, great

numbers of the B-responses follow when only the A-pattern is produced directly. We should certainly expect that if positive visual responses can become associated to form a pattern of simultaneously occurring ones, they can also become associated in a serial order to form a positive pattern of longer duration. I am convinced, that through just such a procedure, I have trained myself to see positive after-images which now last for a minute and a half. Originally they lasted about one-third as long as now.

Another step which I took to increase the duration, and also the distinctness of the after-image, was to greatly diminish the eye movements which I found occurred almost invariably for a few seconds after the retinas were subjected to a sudden change in illumination. The eyes moved from side to side or up and down in various tempi, but usually in that of approximately 0.38 seconds, or about twenty-six times in ten seconds. I learned that, by frowning in a particular way, I could inhibit in a large measure all of these except the first movement. Only after much practice I became able to suppress this one to such an extent that it no longer caused a break in the positive after-image. When I do not suppress these movements, I am able to distinguish the cinematograph positive after-image and then a pulsating one of long duration, such as C. A. Young⁴ described in 1872. The discontinuity of the positive after-image is more pronounced when the period of illumination is extremely short; but in any case, one can make the image continuous by carefully fixating, which process involves suppressing especially the eye movements. As Miles⁵ has shown, it is possible to periodically illuminate the retinas in such a tempo that the usual pulsating positive after-image becomes not only a continuous effect, but also one of very long duration. Miles found it best to reilluminate the retinas at the rate of about four times per second. This tempo very closely approximates our tempo of eye movement which fluctuates, with different individuals, slightly above and below 0.38 seconds.⁶ It would then seem

⁴ Phil. Mag., XLVIII, p. 343.

⁵ George H. Miles, *The Formation of Projected Visual Images by Intermittent Retinal Stimulation*, Brit. Jour. of Psychol., VII., 1915.

⁶ Miles also observed certain involuntary movements of the eyelids (I think these were evidently due to the movements of the eyeballs) which, according to his rough estimate, occurred in the tempo of about 0.4 seconds. The effects of the eye movements can be observed unusually well if the retinas become strongly illuminated for a very brief time interval, and then a phosphorescent patch in darkness is observed. The objective stimulus appears to move in the horizontal or vertical direction in the tempo of about 0.38 seconds, thus producing alternately light and dark spaces where it at any time seems to lie.

that, in order to convert the pulsating positive after-image into a continuous effect, we can reilluminate the retinas at the beginning of each dark space.

II. *The Diurnal Visual Ghost*

The traditional ghosts which fall in this class are such as the revived positive *after-images* and *after-forms* of idols, sweethearts, corpses, or handwriting of particular persons; and they appear in daylight or by artificial light, usually in or on such backgrounds as smooth walls, open fire-places, clouds of whitish smoke, rainclouds, or deep walls. We are not concerned here so much with revived positive after-images as with revived positive *forms* of objective visual patterns. A positive after-image is the pattern of visual responses which is produced directly by the objective pattern fixated, and which may persist after the pattern is removed. The positive *form* which is of primary concern to us here, is the positive after-image plus the negative effect of the background of the fixated pattern; this negative effect coincides with the positive after-image, or in other words, it *assumes* the *form* of the pattern and this induced negative effect of the background and the positive after-image can later be revived simultaneously. Before discussing the *form* of the pattern, it would seem well to consider briefly a certain peculiarity in the behaviour of the mere positive after-image which can be revived in the daytime.

Hering⁷ fixated a gas flame for about twenty seconds and then directed the eyes to a strongly illuminated white paper. He observed first a negative after-effect of the flame which soon passed over into a distinct positive one. He called attention to the fact that that portion of the white surface on which the positive after-image of a bright object develops, may be much brighter than the remainder of the white projection field. McDougall⁸ fixated a white surface, waited until he could no longer detect any sort of an after-effect of it, and then revived the original positive after-image by turning the eyes to a white background. He also found that upon blinking, the positive after-image reappears and frequently remains for a few seconds after the lids are opened. Baird,⁹

⁷ Ewald Hering, *Zur Lehre vom Lichsinne*. Wien, 1878, s. 44.

⁸ W. McDougall, *Some New Observations in Support of Thomas Young's Theory of Light- and Color-Vision*, (I), *Mind*, N. S., X, 1901, p. 55.

⁹ J. W. Baird, *The Color Sensitivity of the Peripheral Retina*, Published by the Carnegie Institution of Washington, Wash., D. C., 1905, pp. 57-59.

also, calling attention to the fact that the effect of a visual stimulus may persist for an unusual time, and too that it may be entirely sub-liminal, made the following statements which should be of considerable interest to us: "A surprising fact in connection with these after-effects was the observer's utter ignorance of their existence. . . . We can only conclude that the functioning of the peripheral retina is followed by an after-effect which is tenaciously persistent and is wholly latent in character; and that this sub-liminal capacity is called into active functioning by subsequent stimulation." Troland's¹⁰ researches lead him to make the following statements: "By use of dimming, after-images can be demonstrated for pre-exposures of an eighth of a second, which leave no noticeable trace on the undimmed field. . . . If the projection field is brightened, the faded negative after-image is *reversed*, and becomes positive. . . . The positive image fades on the brightened field, but upon dimming and rebrightening, again appears."

The revived after-images here mentioned may be anything, a positive one or any of the possible negative ones of a flight of colors which may follow after stimulation with a given color. As to what the particular qualitative nature of the first revived after-image is, depends in the first place upon which one of these possible ones happens to be in progress when the retinas are reilluminated, and in the second place upon the qualitative nature of the stimulus used for reilluminating the retinas. If the eyes are directed to an illuminated black surface, at least many minutes after a white object has been fixated, a negative after-effect can sometimes be observed; but, as Hering pointed out (however, in a special case) this soon gives way to a positive effect; and we might here remark that it is occasionally of an hallucinatory distinctness. These few special cases we shall call diurnal ghosts. The black background revives only indirectly the previously established pattern of white-responses. It produces directly great numbers of black-responses, some of which are associated with and call forth some of the white-responses, and among others, the associated cluster of them which is our previously established positive pattern. If the background is white, the positive white pattern may be produced directly, and the pattern of the previously fixated black background is then produced indirectly. We should never forget that we must reckon with

¹⁰ L. T. Troland, The Influence of Changes of Illumination upon After-images, Paper read before the Amer. Psychol. Assoc. at New York, Dec., 1916.

the entire or general pattern and not alone with any small portion of it. When any portion of the general pattern is caused to recur, all the other portions may reoccur with it, and in the same temporal order as previously, which means simultaneity. Thus when the eyes are closed, a positive after-image of a white pattern may be revived indirectly, but immediately, because when the pattern of the black-responses is caused to recur, the pattern of white-responses occur with them to form a portion of the previously established general pattern.

Our argument concerning the existence of the positive pattern of a white object on a white background, naturally leads us to conclude that the distinctness of the visual effect is dependent upon the number of white-responses which occur in a unit of time when the given retinal areas are stimulated. When I direct the eyes to a white surface, my percept of that surface is characterized by a certain degree of whitishness, and if I make the surface objectively still whiter, the percept is now characterized by a still greater degree of whitishness; which indicates that the first stimulus did not call forth all the white-responses which I, as a visual organism, could manifest when the retinal areas in question were stimulated. The fact that the particular area of a white background upon which the previously established positive pattern of a white surface appears, is unusually whitish, would mean that the effect observed on this limited area is due to a large number of directly produced white-responses plus some others which could be indirectly produced by virtue of the fact that they were previously associated with some of those directly produced ones. Another way of discussing this matter is to say the objective stimulus produces, among many others, some of the responses of the positive pattern directly, and the others of the pattern occur simultaneously with these as previously.

But when we fixate a surface steadily for many seconds, we have still more to consider than the mere positive after-image of the fixated surface. This leads us to a consideration of the *after-form*. If I fixate a white area which lies on a large illuminated black background, the white surface will ultimately disappear. This occurs for two primary reasons. In the first place, the white-structures that function become highly exhausted and give way to black-responses which are associated in this particular temporal order with the white-responses;¹¹ and in the second place, the white of the white

¹¹ I do not see fit to take up space here to suggest why this association exists. I shall simply consider the fact that such an association is established.

area and the black of the black background previous to the exhaustion of the white- and black-structures, induce themselves over one another,¹² and finally there is no border line left between them. In the final after-effect, I notice that the two colors have changed places. We can better express what here takes place if we let W stand for the directly produced pattern of white-responses, Bk' for the black-responses which are associated with and follow the white-responses of W, and Bk'' for the positive or self-induced effects of the neighboring black background. The distinctness of the negative after-effects of the white surface would then be dependent upon the distinctness of each of the two components Bk' and Bk'' in the absence of W. The expression $B' + Bk'' - W$ indicates clearly that we must observe black when the white is removed. If we leave Bk'' out of account, as we can do in a degree by illuminating the surface for such a short time interval (from about $\frac{1}{8}$ to 1 sec.) that the simultaneous self-induced effects are negligible, we find that the negative after-effect which follows the positive after-image of the white surface is very indistinct, and that it is in some cases not even noticeable. But $Bk' + Bk''$ form, in the absence of the objective white, a remarkably distinct after-form, and this form is all the more pronounced if the black background is, relative to the white area, quite large; *of two unequal areas of qualitative sameness the self-inductive effect of the larger one is the greater*. The distinctness of the negative after-form of the black background is determined by the distinctness of each of the two components, W' and W'', in the absence of the objective black. Our shorthand expression which signifies the quality of this negative after-form would be $W' + W'' - Bk$.

To further illustrate the fact that colors induce themselves over one another, we may form a double pattern of adjoining white and blue areas and carefully fixate a point on the border line between them. After this pattern has been fixated for only four or five seconds and the retinas are inclosed in darkness, we observe in place of the white a blackish blue and instead of the blue a whitish yellow. The self-induced blue can be seen even in the daylight if we fixate the pattern carefully for thirty or forty seconds. If the room is made

¹² The fact of the positive simultaneous induction has been recorded, first by Rollet, and then by W. McDougall, *Some New Observations*, etc. (111 conclusion), *Mind*, N. S., X, 1901, pp. 348-353. See McDougall's reference to Rollet and the quotation given on p. 349 of the article just referred to.

dark while the induced blue is quite distinct, *this self-induced blue often remains positive for many seconds*. This would lead us to suppose that when the fixation continues for only four or five seconds, there is a sub-liminal blue induced over the white; that there is a sub-liminal white induced over the blue; and that these self-induced effects remain positive and merely become prominent when the objective stimuli are removed, as when all light is shut out from the retinas.

If a patch of paper which is qualitatively more similar to the blue than is the white is placed on the white area, this will become bluish more readily than will its white background. This patch does not need to be objectively bluish; it is quite sufficient if the similarity is one of brightness only, and the patch by no means needs to be of the same brightness as the blue; it can be a gray that is only somewhat blacker than the white. *The blue induces itself over both the white and the gray, but the more strongly over the gray which is the more similar qualitatively to the blue*. A variety of experiments show that *the greater the qualitative similarity between two areas, the more readily do the colors of these areas induce themselves upon one another*; and it is to be remarked that *this self-induction apparently does not heed retinal distances*. That these simultaneously self-induced colors seem to occur independently of retinal distances, would seem to indicate that the self-induction does not take place in the retinas, but at some place farther back in the visual organism.

If we carefully fixate from five to ten minutes such a pattern as any of those just mentioned, and then wait until no after-effect of it can be observed, the entire positive form of the pattern can often be revived with all the contrast effects, if we remain for a time in weak illumination and then fixate such a bright surface as a field of snow. The positive after-form of a white object soon disappears on the snow, giving way to a negative one; and the second positive after-form that appears, if it appears at all, is as a rule very indistinct. If now, after having fixated the snow, we decrease the illumination on the retinas by turning the eyes to a dark wall or by passing into a moderately well-illuminated room, everything in the visual field is often negative at first; but as the general negative effect fades, the positive form of the previously fixated pattern often comes into prominence. If the pattern fixated is made up of two adjoining areas of red and blue, this pattern can be revived by looking at the snow, and the red and blue may change places a number of

times before they completely vanish.¹³ After they vanish, they can be again revived by directing the eyes for a short time to either a blue or a red surface, by closing the eyes so long that the red of the blood-saturated eyelids can be noticed, or by walking rather rapidly on the east side of and very near to a high picket fence through which the low western sun shines. The difference here between the positive and negative after-forms can be determined only by remembering the previous relative positions of the red and blue in the objective pattern; if the objective red lies to the right of the blue, and this same relative position of the subjective colors is present, the revived after-form is positive, otherwise it is negative. Thus the positiveness or negativeness of the general pattern is experienced only as the one or the other of the two possible positions of the colors.

One of my former students, in an attempt to observe what he had heard me speak of as 'the positive after-images of long duration,' fixated his mother for many minutes and then passed into a room which was only moderately dark. After many such attempts he succeeded in reviving a distinct positive after-form of his mother's face. He later complained to me that he had very much difficulty in securing the 'positive after-image.' He said it was quite distinct only a very few times, and that it was generally not to be recognized. When he told me of the odd method he used, it became at once evident that he had misunderstood the instructions, which had fortunately never been explained explicitly to him. I have followed out this new method of procedure, and a few times I have succeeded in reviving the positive after-form of the person's face by turning the eyes alternately to white and black backgrounds. Once I succeeded in seeing the white of one eye. The other eye had the appearance of a mere dark cavity in the head. As a general rule the eyes are represented by mere dark spaces, the nostrils seem to be very much inflated, the nose seems unusually short, the cheeks unusually hollow, and the ears are often two or three times their natural length, and quite pointed.

I recently discovered that if one fixates for five or six minutes, e. g., a moderately well-illuminated person, somewhat peripherally, and then steadily fixates a point on a large

¹³ For the first description of this behaviour of the red and blue pattern on the snow, I am indebted to Mr. W. C. Bock, Research Fellow in Psychology at The Ohio State University. Mr. Bock said the red and blue once interchanged two or three times before they disappeared completely.

smooth wall for three or four minutes, perhaps in one trial out of fifty a ghost of the previously fixated person appears and stands out as if in high relief on the wall. When this ghost appears, it usually remains for only about four seconds, but after a lapse of about four seconds it reappears. I have observed it to appear thus perhaps as many as twenty or thirty times; fourteen such periodic appearances is the greatest number I have actually counted at a single sitting. Often the features of the person can be seen remarkably well, but sometimes the eye regions are too dark, the nostrils too large, and the ears too pointed to enable one to say whether it looks more like the person fixated or the Devil.

In this experiment, the visual structures for the color of the wall were first highly exhausted by steadily fixating the surface for three or four minutes so that the visual responses, which the wall at first called forth, would play an insignificant rôle in inhibiting the positive after-form of primary interest. The muscles of the iris became in the meantime well recuperated, began to contract and expand, and thus caused the peripheral regions of the retinas to become differently illuminated in the slow tempo of about four seconds. At each expansion of the pupils, the ghost appeared, and it remained present until the pupils contracted, thus darkening the retinas and accordingly reviving the negative form of the pattern. One outstanding fact is that when one breathes slowly, the ghost remains longer each time, and it is easily observed that the fluctuations in the size of the pupils tend, under these conditions, to occur in the same tempo as do the movements involved in breathing.

It would seem reasonable to suppose that in this particular experiment the peripheral ghosts are more easily obtained than the foveal ones, merely because the peripheral regions of the retinas become affected in a greater degree by each contraction or expansion of the pupils; the illumination of the foveal regions must become thereby only slightly altered, if at all. We have seen that the foveal positive after-form can be revived, either directly or indirectly, by directing the eyes to a white or to a black surface, or by changing the illumination in any other way. An idol-worshiper who has stood in awe of his idol for a long time, might later change the illumination of the retinas properly to revive a positive after-form of his god by looking at a wall, at a cloud, into an open fire-place, or perhaps into a dark well.

C. CUTANEOUS GHOSTS

When we turn to the field of cutaneous sensations, we find positive after-patterns which follow fundamentally the same laws of behaviour as do the visual positive after-images. Periodically recurring cutaneous positive after-effects which appear and disappear in a similar way as do the visual positive ones, are quite frequently observed.¹⁴ We shall discuss as briefly as possible the results of some detailed experiments in this field, and shall attempt to make clear the purpose for so doing by returning occasionally to the visual phenomena.

The subject laid his arm on a table and closed his eyes while I lightly stimulated the fore-arm with a compass-point, the immediate end of which was a nail head with a diameter of 1.6 mm. When this was held at a single place for a long time, the subject made the following verbal responses: "One point," after about twenty-five seconds: "None," after about five seconds: "One," and so on. The periodicity of the recurrence varied with the different subjects, and also with the same individual from time to time. The verbal responses which expressed the periodicity of recurrence, varied for each portion of the arm that was stimulated. As soon as the single nail was one time no longer felt, I applied the second nail of the compass to the skin at a distance of about six centimeters from the original point. The verbal responses heard were: "One, and you shifted it," after three or four seconds: "Two." Then I removed the first point and the subject made no response, so I asked how many points were present, and the reply was: "Two," and immediately: "Now it's only one." Even in this rough experiment, I finally found myself able to predict with considerable certainty at what times the subject would say two points when only a single one was being applied.

Then on the other fore-arm, I applied the two compass points simultaneously for twenty seconds, made a pause of twenty seconds, then again stimulated the same points for the same period, and so on. Finally it was necessary for me to stimulate only one of these points in order to cause both to respond simultaneously and positively. The reaction time of this cutaneous ghost, i. e., the reaction time of the induced response, was apparently no greater than that of the directly produced one, and no instrument has measured this; in all probability it is so very short, that until the contrary

¹⁴ See, for example, Langfeld and Allport, *An Elementary Laboratory Course in Psychology*, Exp. 19, p. 32.

is proved, we may say it approaches the zero value.¹⁵ (The reaction time of the verbal responses we shall not consider, merely because we have not chosen to discuss verbal ghosts.)

In the last experiment, I applied, after the systematic training, a single nail head, and the subject felt two, but the distance between the two responding areas was seldom accurately estimated; it was generally underestimated, and sometimes the points were judged to be almost together, when the real distance was 5 cm. I applied also the second nail head at a distance of 1 cm. from the first one; and the subject responded just as if the second stimulus had not been applied. This experiment indicates that the presence of the two objective stimuli within the 'Weber's circle' has caused investigators to assert that the individual can be trained to detect their presence there. But the simple fact that a single stimulus is often as good as two, indicates that the threshold does not become reduced as has been supposed.

In order to establish a reaction time for the cutaneous ghost, I chose a decidedly new area on the arm, and applied only one compass point for ten seconds, and then both simultaneously for ten seconds, before I made the regular pause of twenty seconds. I soon found that when I stimulated the first area only, it responded alone for about ten seconds, and then the other area responded suddenly so strongly that, when the second compass point was applied to it, this was a superfluous stimulus for the second area; the area was already responding as if to this stimulus. In this case, the reaction time of the ghost was about ten seconds. This was really a pseudo-reaction time to the stimulus used; the real reaction time was that time which lapsed between the presentation of the stimulus and the occurrence of the most immediately produced response. The second area now responded, not only when it was directly stimulated, but also when the first area became alone directly affected. We must then call the indirectly produced response a cutaneous habit, because it now occurs more frequently than originally. The usual frequency of occurrence is due to the fact that a greater number of the stimuli of the environment produce it, either directly or indirectly. Any response which is produced only directly by a stimulus is an instinctive one.¹⁶

¹⁵ See my article on 'The Term Reaction Time Re-defined,' which has been accepted for publication by this journal, but which has not yet appeared.

¹⁶ For a more detailed discussion of the problems of instinct and habit, see my articles: *Ueber einfache Bewegungsinstinkte und deren künstlichen Beeinflussung*; *Zeitschrift für Sinnesphysiologie*, 1915, and in connection with this, the one on *Übereinandergelagerte Rhythmen bei dem Menschen*, in the same journal, 1916.

Fundamentally the same training method can be employed to develop the traditional paradoxical warm- and cold-spots. I stimulated one normal warm-spot with a heated nail head, and at the same time, I applied an ice cold nail to a normal cold-spot for twenty seconds. I then made the usual recuperation pause of twenty seconds, and so on, for an hour. At the close of the period, I found that when I adequately stimulated only one of these spots, the subject frequently judged both to be present. When I asked how far apart they seemed to be, the reply was: "They are almost together." The spots which were stimulated in the training, were in many cases, separated by a distance of about eight centimeters. At another sitting, I stimulated two spots of similar nature alternately, and at the end of the period the subject frequently responded, "Cold," when only the warm-spot was being stimulated. Likewise, the verbal response was often, "Warm," when only the cold-spot was being adequately stimulated. It is interesting that both of these sensations, even more so than the simple cutaneous ones, usually seemed to originate from about the same place on the skin. I later trained two spots in the same way, but by using one cold nail head and one which was at about the same temperature as the skin area of the subject. After the training, the subject reported, "Cold," when only the ordinary cutaneous stimulus was presented to its original spot. This is a paradoxical cold spot produced in the training by using an ordinary cutaneous stimulus and one in which the quality of coldness was emphasized. The cold-response was a negative cutaneous response or a negative cutaneous ghost. The cold-response was the habitual one, the directly produced one was the instinctive one.

We must not forget that we can speak in the same sense of visual instincts and habits. Apparently, in the absence of eye movements, the star gazer may see two or more stars when only one is in the field of vision. According to the results of our cutaneous experiments, we should expect that if the retinas are stimulated by a pattern of stars, this pattern may later be partially or wholly revived when only one of the previously stimulated retinal areas becomes affected by a single star. Also, when the person first directs the eyes to the single star, it might stimulate alternately two retinal areas. Then if the eyes remain still while only one of these areas becomes affected, we should expect a purely subjective or induced star corresponding to the other retinal area to appear and disappear. The observer would accordingly see two stars occasionally. We should expect the induced star

to be more transient than the one for which the objective conditions remain present.

Instead of a constellation of stars, I used a pattern of white spots which were round pieces of paper with the diameter of about 1 cm. I opened the door of the dark-room so widely that everything in the room could be distinctly seen. The observer then carefully fixated two spots, one centrally and one peripherally. These papers were pasted on a black cardboard and were separated by a distance of four centimeters. The distance of the observer's eyes from the spots was about one meter. After a few seconds of careful fixation, I closed the door; and, in the darkness, I placed a black cardboard over the peripheral spot without permitting the subject to know what change had been made. I then opened the door slightly, so that the remaining spot could be seen, and when this was carefully fixated, it was observed to periodically appear and disappear; and many subjects occasionally saw a ghost of the previously perceived peripheral spot. Then, in complete darkness, I uncovered the hidden paper and rotated the cardboard slightly so that the peripheral spot was displaced from its original position by about two centimeters. In the twilight, the observer fixated as usual, and three spots were occasionally seen simultaneously—the two for which the objective stimuli were present, and also the ghost of the previously observed paper. The results yielded by other similar experiments are fundamentally the same as those here reported, and correspond nicely with those obtained by experimenting with the unprotected surfaces of the body.

It may be of interest here to note that for the majority of the observers, the peripherally fixated spot disappears even more readily than the one which falls on the fovea. This occurs even when the eyes are exceedingly well dark-adapted. If, however, a circle of white spots is placed around the foveal one, the central spot, whether fixated foveally or peripherally, disappears, at least for some of the observers, much more frequently than any of those which form a part of the circle. It is often to be noticed that each of the spots induces itself in all directions. Between any two of the circles, the induced effects supplement each other and thus cause a more or less unbroken circle of white to be formed around the central spot. The relatively large area of black which surrounds the central white paper, induces itself in all directions; the white of the small area also induces itself in all directions; and finally there remains no line of demarkation between the spot and its background. When this occurs, we may say the white area dis-

appears. If the white is made larger, it will disappear eventually, but not as readily as when it is small. Of two unequal areas of qualitative sameness, the self-inductive effect of the larger one is greater than that of the smaller one; and, consequently, the larger area does not become as strongly influenced by the self-induced effects of the background. Moreover, the more similar two areas are qualitatively, the more pronounced are the self-induced effects upon one another. It is for this reason that those investigators, who were interested in the absence of the rod processes in the foveal region, and performed their experiments in the twilight with just perceptible white areas, came to the conclusion that the fovea is a blind spot in twilight vision. A white spot, when carefully fixated in ordinary daylight, will disappear, but usually not as readily as in twilight where it is easily made qualitatively more similar to its large background.

The experiments thus far reported show clearly that there is really no fundamental difference between the behaviour of visual and cutaneous ghosts. It seems as if all forms of self-induction are fundamentally the same. Other more elaborate cutaneous experiments which follow, make the similarity between visual and cutaneous ghosts still more apparent.

Instead of the two points of the compass, 315 nail heads were used in training an area on the arm. At distances of 0.4 cm., holes were drilled in a 6.4 x 5.0 cm. block of wood, and the nails were driven into these in such a way that the surface of nail heads received the proper curvature to fit nicely over the arm of the subject. This block was placed on the arm and was allowed to remain for twenty seconds; after a pause of twenty seconds, it was again placed on the arm, and so on, for a period of thirty minutes. After a single half hour of such training, a single nail head of the compass was applied within the trained surface, and the subject reported: "Many, at least a half dozen." A week later, all the effects of the training had disappeared, and after three successive periods, thirty minutes each week, the effects began to persist from one period to another. We have in this case an indirectly produced positive pattern response which is fundamentally the same as any of our visual ghosts. In the case of the nails, the single nail which was applied and caused the pattern response to occur, is analogous to the insignificant illumination of the retinas which revived the elaborate visual pattern. Perhaps not all the 315 nail heads appeared in the revived

cutaneous pattern, and we are just as far from supposing that every single element of the previously perceived visual patterns appeared in the revived ones.

In my article on reaction time, which was previously mentioned, I made brief reference to an experiment similar to the one just described, the only difference being that a smooth surface of wood was used instead of the block of nail heads. After the smooth surface had been systematically applied to a surface of the body for a few days, it was found that a single point, preferably of the same material as that used in the training, so effectively revived the previously perceived cutaneous pattern that a second compass point was a superfluous stimulus when applied lightly within the trained area; the second point was not detected because at least the particular area to which it was applied was already responding as if to this stimulus. In our present experiment a second nail head was a superfluous stimulus when applied to many points within the trained area, because a large number of limited areas within the large one were already responding as if to so many nail heads.¹⁷

D. KINAESTHETIC GHOSTS

We shall conclude our ghost theory by discussing some forms of behaviour which are more tangible. A cockatoo moved its foot back and forth near its beak as if it were playing a Jew's-harp in the tempo of 0.21 seconds. I secured a Jew's-harp and played a monotone on it by moving my right hand in the same tempo in which the cockatoo moved its foot. At first the bird would not play with me, but I kept on playing to it occasionally; and finally, for some reason unknown to

¹⁷ After these experiments on cutaneous sensations were completed, my attention was called to the following interesting, but purely theoretical statement made by William James, *Psychology*, II, p. 158: "When any point of the sensitive surface has been frequently excited simultaneously with, or immediately before or after, other points, and afterwards comes to be excited alone, there will be a tendency for its perceptive nerve-centre to irradiate into the nerve-centres of the other points." I wish to restate that part of this law which is of primary interest to us as follows: When any point of the sensitive surface has been frequently excited simultaneously with, or immediately before, other points, and afterwards comes to be excited alone in the same way as previously, there will be a tendency for the other points to respond simultaneously with or immediately after this one. It has been reported that a few people can recite, e.g., the ABC's from Z to A as readily as from A to Z without having the special Z to A training, but at no time have I observed such a duplicity of the association in my many human and animal subjects.

me, it began beating in the air with its foot. I ceased playing, but the bird played on. It played a group which contained sixty-one elements (a 61-group), and when it ceased moving its foot, I disturbed it for about a minute by shaking its perch, so that it could not play during the time; it had to clinch the perch fast with both feet to avoid falling. After this pause for the activity in question, I occasionally played the harp, and whenever the cockatoo started playing with me and played the 61-group, I shook the perch for a minute. Instead of bringing about a pause for this unitary act by shaking the perch, I could just as well have fed the beast. Whenever it played anything other than the 61-group, I left the bird unmolested, and it often played again after a short intermission. When it sooner or later played the 61-group, I shook the perch, and only after about three weeks of such training, I found that almost every time I entered the cockatoo's room and started playing the harp, the bird would follow, and in its silent way play the 61-group. I soon found that a minute was an unnecessarily long pause—from thirty to forty seconds sufficed. When I played the harp sooner than thirty or forty seconds after the cockatoo finished the 61-group, it would make either no noticeable response to my music, or, play some other group. Since I did not desire to establish any more than the 61-habit-group, I took special care to make long pauses.

The stimulus which originally started the 61-group was unknown—we shall call it 'X.' The stimulus which later produced the 61-group indirectly was my activity of playing the Jew's-harp—we shall call it 'J.' J produced simultaneously auditory- and visual-responses which were followed by the discontinuous kinesthetic-response, which was the 61-group. We shall assume that X was followed immediately by the 61-group; in other words we shall assume that X was the most adequate stimulus for the initial element of this unitary act. Whenever the 61-group was the direct response to the stimulus X, we may call it an instinct, the elements of which occurred in a constant tempo, a constant direction, and in a relatively constant amplitude of movement, thus making it a unitary group or act. The elements of the group were so many conditioned reflexes; the first was conditioned by X, the second by the first, the third by the second, and so on to the end of the innately associated series. Only those reflexes which are similar to one another are innately associated to form unitary groups of reflexes. Instead of speaking here of association, we might speak of induction, and accordingly say the nervous

correlate of the first reflex of the unitary group was more similar in its chemical makeup to that of the second than to that of the third reflex and consequently induced action in the second structure; and for the same reason, the second then induced action in the third instead of the fourth structure, and so on to the end of the series of the inherently similar structures.

It would certainly be remarkable if X was of such a simple nature that it, when applied to the bird, caused a single reflex, but to avoid argument, let us suppose that this was the case; it makes really little difference what we suppose the very first reflex is like. The structure for the first reflex responded; this structure was similar in various degrees to others and accordingly induced action not merely in a single one, but in a number of others which in turn induced action in their next most similar ones, and so on. We accordingly get a number of qualitatively similar but quantitatively different (occasionally, however, quantitatively the same) groups marching along in the same tempo, and terminating at different intervals. Moreover, new groups may start at any time, e. g., the twentieth structure element or group of simultaneously occurring elements may induce action in the initial element of a new group which none of the preceding elements were capable of phasing. Kymograph records of well trained animals show that groups really do run in just such a temporally superimposed order; and these records also show us that when a certain number of these groups run their natural or innately determined courses simultaneously, many, and in cases apparently all of the remaining ones cease. If some of them continue, the beating member begins to move in a slightly different way, perhaps in a different direction, tempo, or general amplitude of movement; and, without waiting for a pause, we accordingly begin to count a new group which continues until a certain number of these cease simultaneously. Since such qualitatively similar groups begin and terminate at such irregular intervals, and since all of them are expressed by the same beating member, it becomes clear, for this if for no other reason, why the amplitude of movement of a given member always varies—even though the fluctuations may be slight—while the tempo and direction of movement may remain extremely constant for a considerable time.

Even in such a simple case as the one just discussed, we by no means observe a simple unitary group, but a great number of qualitatively similar ones which might be produced simultaneously by a properly designed pattern of stimuli. If

in the case of the 61-group such a thinkable pattern should be presented, all the groups that have concerned us would start simultaneously; and, the general amplitude of movement must necessarily become less as the quantitatively different groups terminate one after another, and occasionally several at the same time. Such a phenomenon of fatigue, we observe in the field of visual sensations when the retinas become affected for only a few seconds with an intense visual stimulus. If the psychical state produced is one of whitishness, it becomes gradually less and less distinct.

We have supposed that the primary effect of the stimulus X is the first reflex, i. e., the first beat the bird executed, and the remaining sixty beats then compose the positive after-effect or the kinaesthetic instinctive ghost. Now, if we can revive the entire 61-group by using some stimulus other than X, we may speak also of the kinaesthetic habitual ghost. The stimulus J serves this purpose. We may now speak more generally and say the macro-61-group is a kinaesthetic pattern conditioned by micro-visual and auditory groups. As is the case with the visual and cutaneous ghosts, we also find it impossible to produce the kinaesthetic one while the structure correlates are in a state of exhaustion; we must in all cases wait until an adequate recuperation pause for the structures has elapsed.

Our reasoning concerning the innate associations of reflexes would lead us to suppose that when the 61-group became a habit, by virtue of the fact that it became associated with at least one other group that appeared frequently, the structure correlate of its first element and that of the last element of the conditioning group became chemically more similar than originally. Without stopping in this paper to discuss a theory of how this might take place, I shall dismiss the subject for the present by merely suggesting that, if the structure correlate of the first element of the 61-group is stimulated to function while the last element of the micro-group (in this particular case a micro-group) is still in a state of dissimulation, a part of the former may become included in the latter substance.